Ch(5) : Renewable Energy

Renewable Energy replaces conventional fuels as it is clean & will never run out.

There are many sources for renewable energy like wind & solar. They suffer from high fixed cost but low running cost.

1) Solar Energy

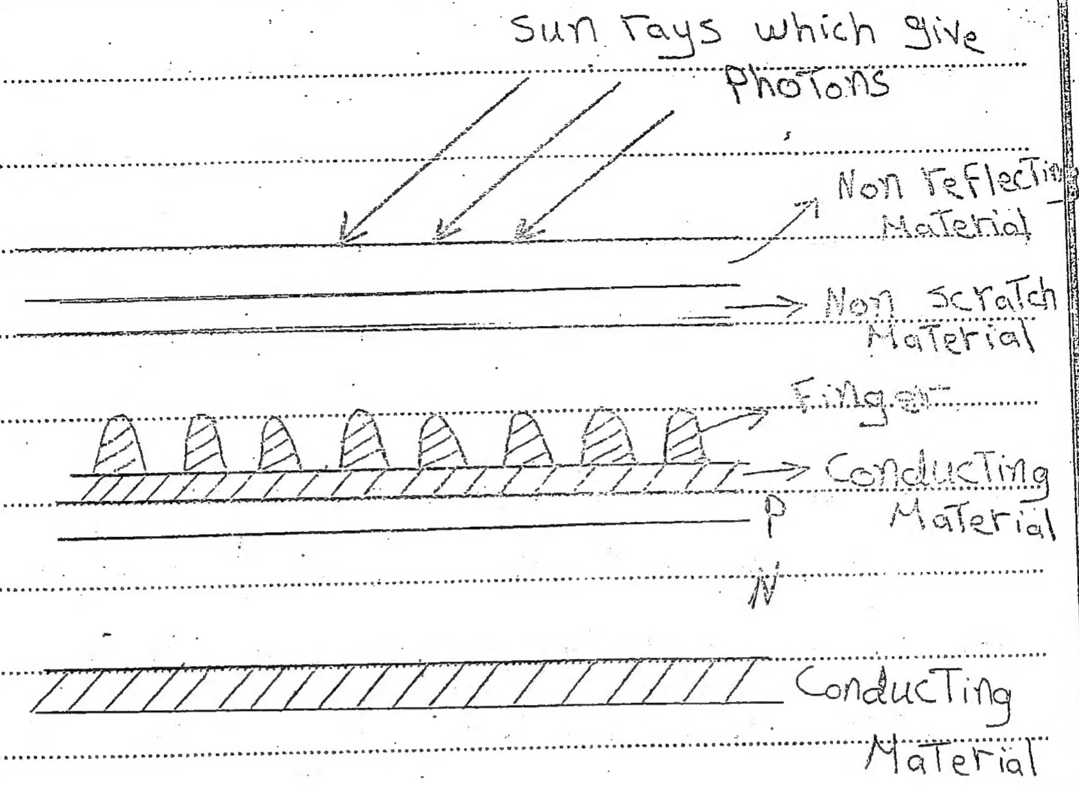
It is the direct conversion of solar energy into electrical energy by means of the photovoltaic.

The silicon solar cell is PN type semiconductor, 2 X 2 cm in area & 0.25 to 0.35 mm thick.

- N-Type Semi Conductor is Formed of doping atoms From 5th group (phosphorus - Arsenic) so it shares one electron with The Silicon . Since The extra electron has a negative charge so it's called n-Type.

- P-Type Semi Conductor is Formed of doping atoms like Boron or Gallium which have Three electrons in Their outer level . So, when This atom is adoped into (Si) , it Make a holes (positive charge) so it's Called P-Type .

- If a piece of P-Type silicon is placed in close contact with a piece of n-Type Silicon , Then a diffusion of electrons occurs From n To P Type & They recombine with holes on P side . This region is called depletion region as it no longer Contain any Mobile Charge Carriers.



Non reflecting Material To Prevent reflection of rays come From Sun.

Non Scratch Material To Protect PV.

Conducting Material To Collect holes & electrons.

هام جدا

Advantages of pV

1. It provides green energy.
2. It's free & available energy.
3. It can be used locally (Reducing losses).
4. operation & Maintenance costs are low.
5. pV is totally silent (No noise).
6. pV has no mechanical parts.
7. Easy to install.
8. used in spacecraft applications.

Disadvantages of pV

1. No power at night or during cloudy or rainy weather.
2. It requires additional equipment (such as inverters & Batteries).
3. Low efficiency (14% → 25%).
4. Needs continous cleaning.
5. For high power, pV array requires a large area which is difficult inside or near cities.

Sun Tracking :

Trackers direct solar panels toward the sun. These devices change their orientation throughout the day to follow the sun's path to maximize power.

Trackers help minimize the angle of incidence between the incoming light & panel.

a) Fixed Panel : put it fixed such that taking max. power

b) one axis Tracking

rotate on one axis , track the sun light during the day from sun rise to sunset.

c) Double axis Tracking

Two axis , one axis to track sun from sun rise to sunset & the other axis to track sun during different seasons.

* Maximum power point Tracking (MPPT)

It is a method to track maximum power point
(Explain sun Tracking + we want to operate at V_{max} , I_{max})

Q: Discuss with the help on neat sketches the effect of هام جداً

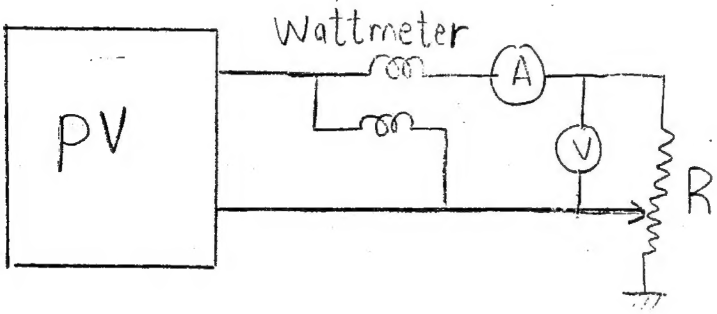
ⓐ load resistance

ⓑ Temperature

ⓒ Insolation (irradiance) "شدة ضوء الشمس".

Solution

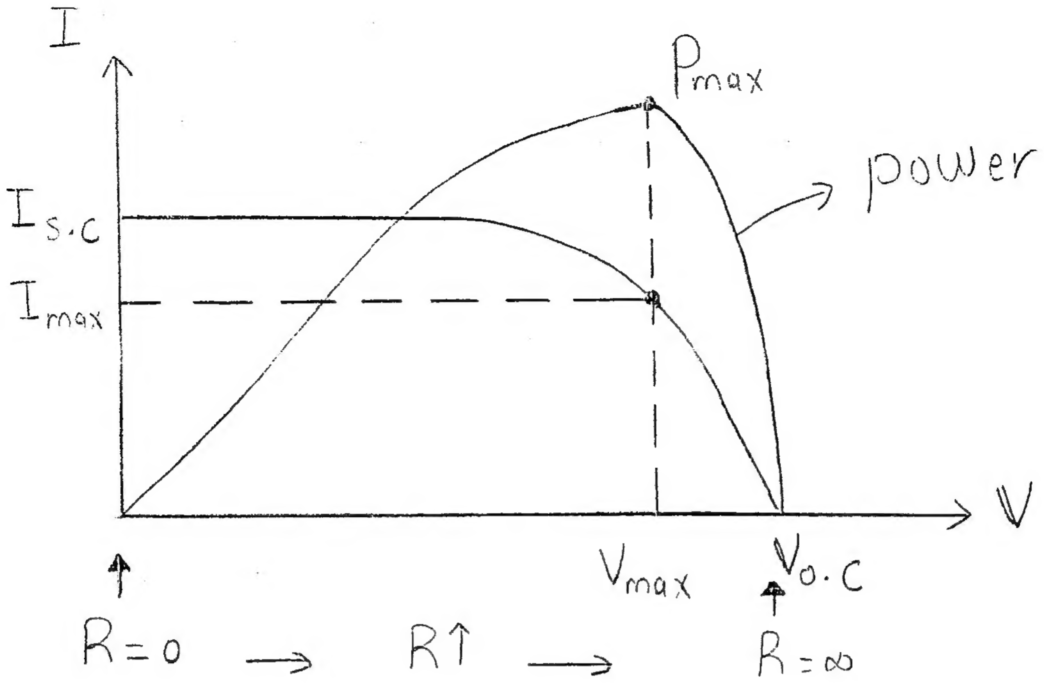
ⓐ Load resistance



→ Vary the load from $R=0$ (short circuit) till ($R=\infty$) (open circuit)

→ Measure the voltage, current and power of PV panel

→ As $\boxed{R\downarrow}$ → $V\downarrow$
→ $I\uparrow$ until saturation
→ $P\uparrow$ until $P=P_{max}$ then P decreases

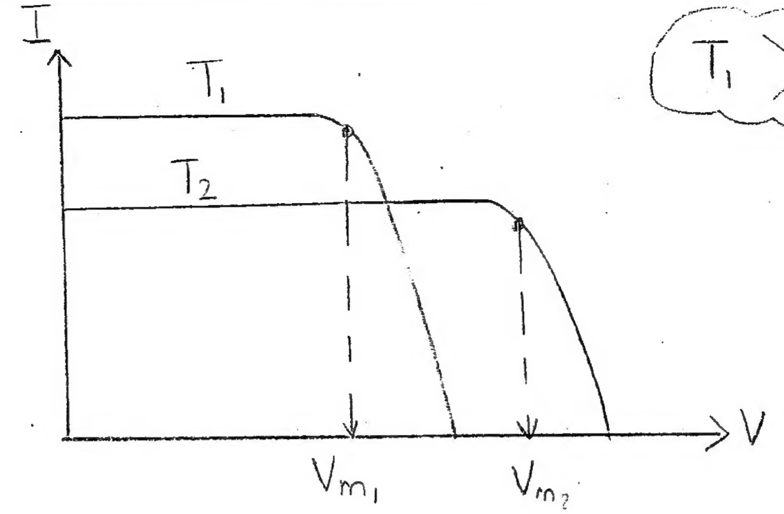


PV is usually designed to operate at point of Maximum power (Knee of IV curve)

$$P_{max} = V_{max}\, I_{max}$$

(b) Effect of temperature

$T_1 > T_2$

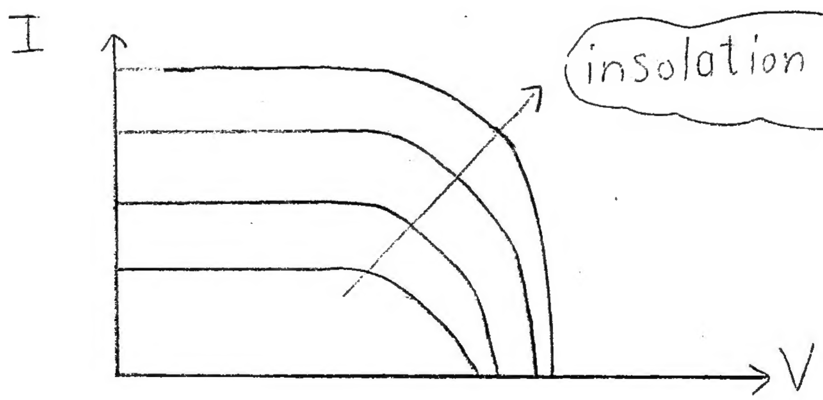


As T↑ → I increases by small value
→ V decreases by large value
→ power decreases ($P = V\downarrow\downarrow \, I\uparrow$)

* Solar cells perform better at low temp.

As T↑ → power ↓

(c) Effect of insolation



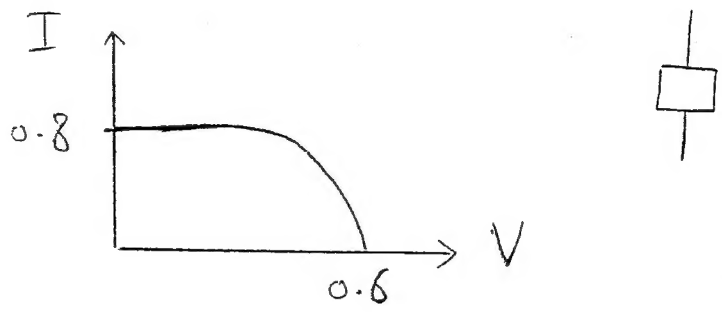
As sun insolation ↑ → I increases by large value
→ V increases by small value
→ power increases

Insolation ↑ → power ↑

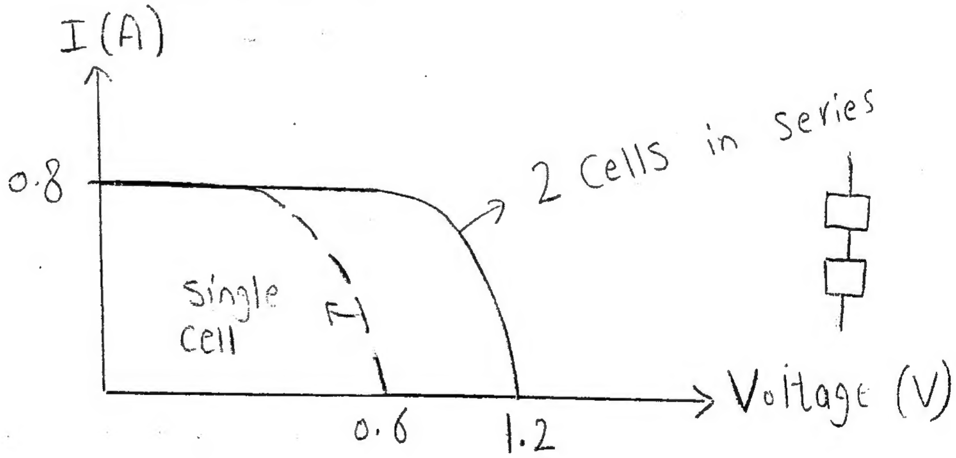
Connections of Solar Cells

* Multiple pV modules Can be Connected in parallel to increase current or in series to increase Voltage. This is Called pV array

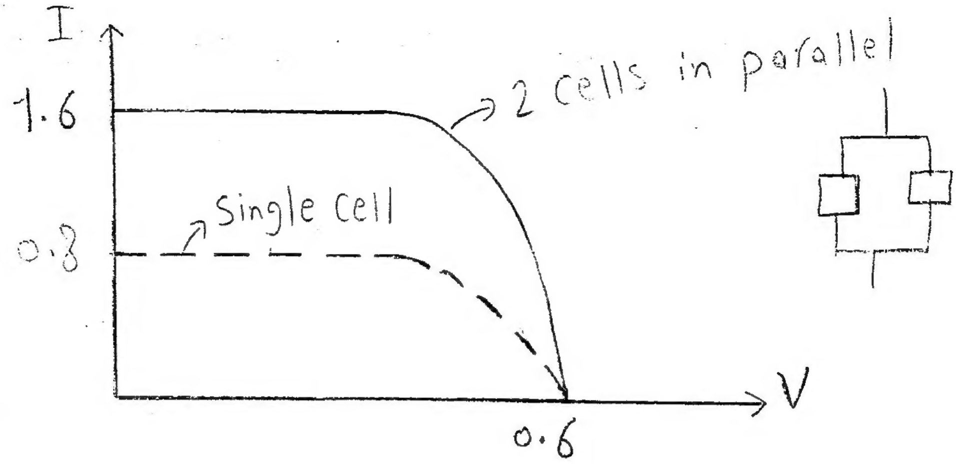
ⓐ Single Cell



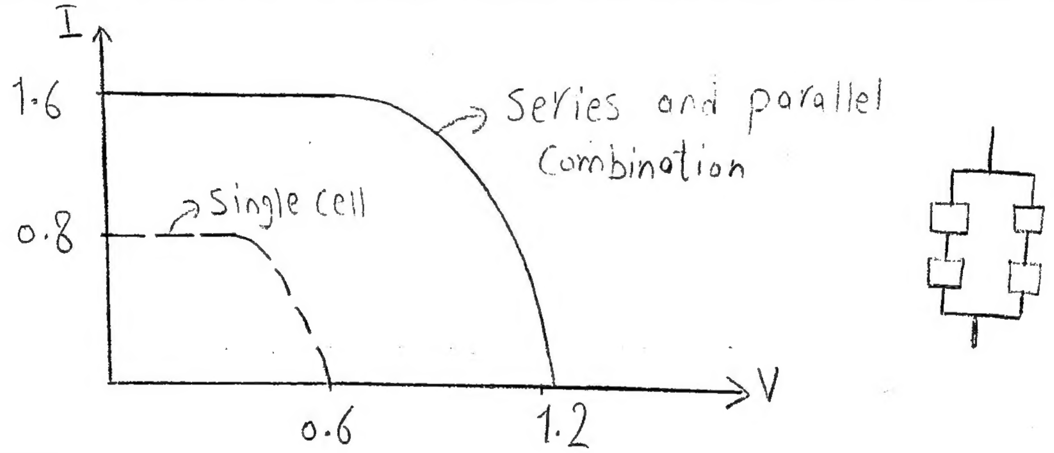
ⓑ Two Cells in series



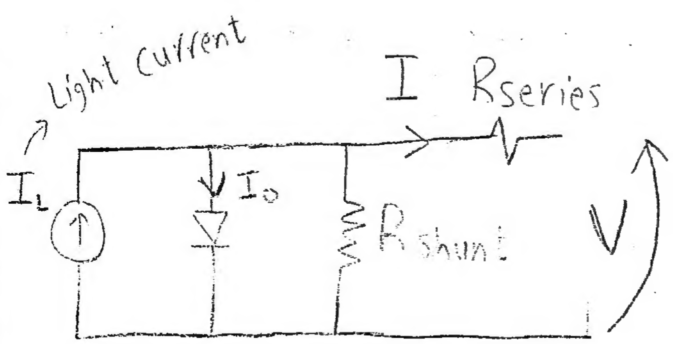
(c) Two cells in parallel



(d) Series and parallel Combination of cells



* Equivalent circuit of Solar cell



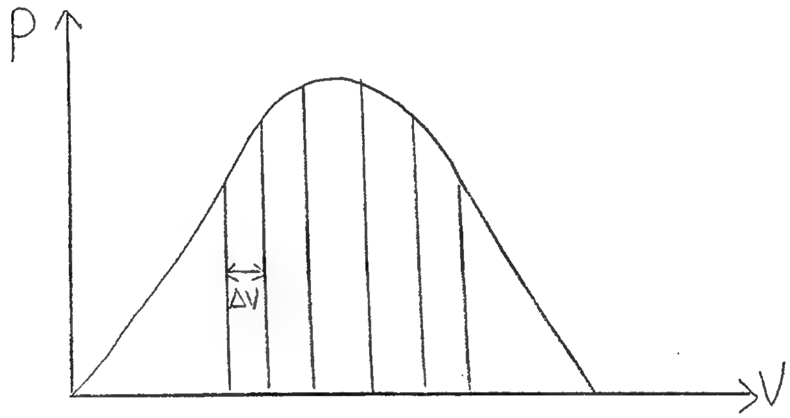
Several techniques used for MPPT:

1. Constant Voltage method
2. open circuit Voltage method
3. Feed back Voltage (current) method
4. peturbation & observation method (P&O)
5. Incremental Conductance (IC) method.
6. Fuzzy logic method
7. Neural network method

* Explain 2 methods of MPPT techniques: *

→ Method 1: peturb & observe Technique (P&O)

* Increase the Voltage by ΔV
* Calculate power ($P = VI$)
* Continue untill power starts to decrease
* Then decrease the Voltage by ΔV & calculate power & so on till reaching P_{max}.



The disadvantage of this method, that we don't operate exactly at P_{max}, But we operate around This point.

→ Method 2 : Incremental Conductance technique

power is maximum when $\frac{dp}{dV} = 0$

$$\therefore \frac{\partial (VI)}{\partial V} = 0 = V \frac{\partial I}{\partial V} + I \frac{\partial V}{\partial V}$$

$$V \frac{\partial I}{\partial V} + I = 0$$

$$\therefore \text{At } P_{max} \Rightarrow \underbrace{\frac{\partial I}{\partial V}}_{\text{incremental conductance}} = \underbrace{\frac{-I}{V}}_{\text{instantenous conductance}}$$

So we change I, V by ΔI, ΔV until this relation is achieved

EX (1)

Radio repeater station works on pV continously 24 hrs/day. It operates on 24V and average current (2A).

The insolation continues for 6 hrs/day as an average

The available pV units have a voltage (12V) and a current (2A).

Take a safety factor of 1.25.

Design the pV units and draw a circuit diagram.

Solution

→ Number of panels in parallel :

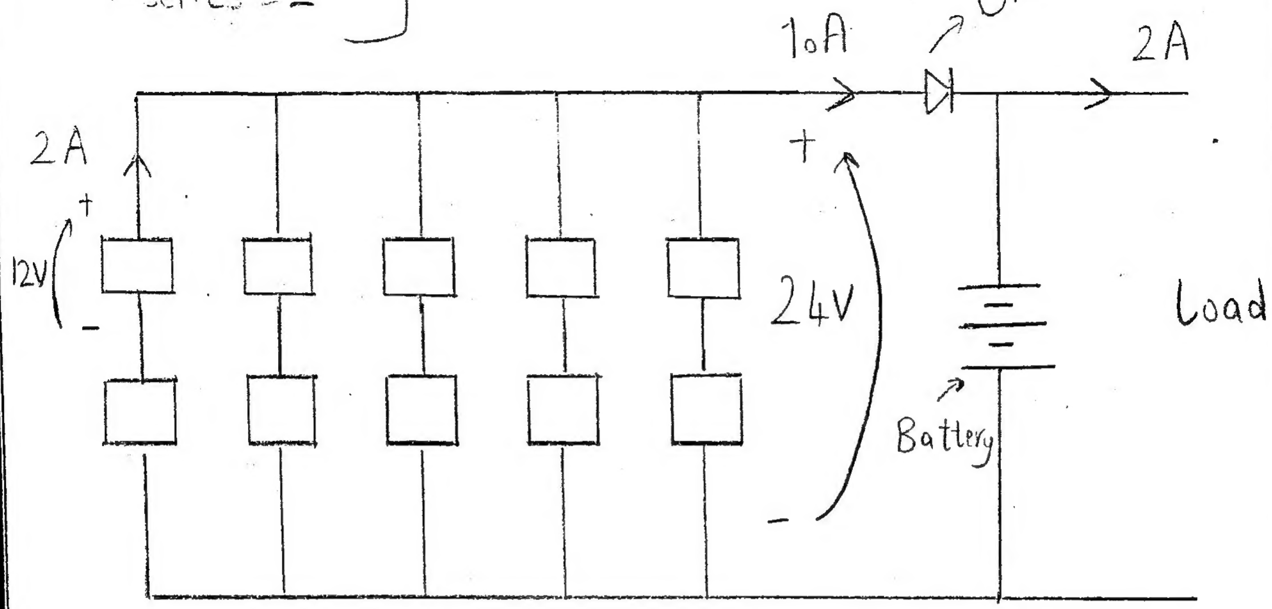
$$= 1.25 * \frac{\text{Ampere hour}|_{load}}{\text{Ampere hour}|_{pv}} = 1.25 \frac{[I_{avg} * 24]}{[I_{pv} * 6]}$$

$$= 1.25 \frac{2 * 24}{2 * 6} = \boxed{5 \text{ panels}}$$

→ Number of panels in series . $\frac{V_{load}}{V_{pv}} = \frac{24}{12} = \boxed{2}$

Circuit diagram

$N_{parallel} = 5$
$N_{series} = 2$ $\Bigg\} \rightarrow N_{total} = 2 \times 5 = 10$



* The diode → To allow energy flow in one direction only
(يمنع البطاريات من تغذيه ال pV)

* The Battery → To charge when pV panels are working during sunlight and supply the load when pV panels are not working (No sunlight)

problem

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A Station used to reinforce TV antenna uses pV panels of 2.8 A, 24 V.

The Station works for 16 hours / day.

→ During these 16 hours the station needs 4A, 48V.

→ At off-time the station needs 2.1 A, 48 V to cover essential loads.

→ The minimum sun-time is 11 hours / day

→ Consider Safety Factor = 1.2

Find:

(i) I_{avg} required to cover the load

(ii) Number of series panels (N_s)

(iii) Number of parallel panels (N_p)

(iv) Total number of panels required to cover this load

(v) Draw complete circuit diagram

Solution

* pV panels $\rightarrow$ 2.8 A, 24 V
* Load: ON-time (16 hr) $\Rightarrow$ 4A, 48V
  off-time (8 hr) $\Rightarrow$ 2.1A, 48V
* Minimum sun time = 11 hour
* Safety factor = 1.2

(i) $I_{avg} = \frac{[(16 * 4) + (8 * 2.1)] * 1.2}{24} = 4.04A$

$\boxed{I_{avg} = 4.04 A}$

(ii) $N_p = \frac{\text{Ampere hour}|_{total}}{\text{Ampere hour}|_{pv}} = \frac{4.04 * 24}{2.8 * 11}$

$N_p = 3.148 \Rightarrow \boxed{N_p = 4}$ 4 panels in ~~series~~ parallel

(iii) $N_s = \frac{V_{load}}{V_{pv}} = \frac{48}{24} = 2$

$\boxed{N_s = 2}$ 2 panels in ~~parallel~~ series

(iv) $N_{total} = N_s * N_p = 8$ panels

Circuit diagram